



# Trans Forum™

News From Argonne's Transportation Technology R&D Center

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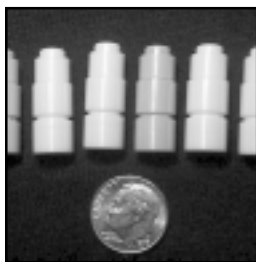


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## Robert Larsen: 'Walking the Talk' on Government, Industry Partnerships

*Director of Argonne's Center for Transportation Research Completes 3-Year Term on SAE Board*

As director of Argonne's Center for Transportation Research, Robert Larsen oversees a \$15 million budget. His staff includes 38 full-time researchers working on U.S. Department of Energy (DOE) transportation programs in hybrid electric vehicle powertrains, advanced diesel and spark-ignition engines, alternative-fuel vehicles and infrastructure technology, and vehicle simulation and energy-consumption modeling.

Yet Larsen believes that just as important as studying cars and engines is building bridges. Since joining Argonne in 1984, he's been a strong proponent for "establishing good working relationships that bridge the gap between industry and government, especially with the Society of Automotive Engineers (SAE)."

Larsen's emphasis on collaboration has led to his ongoing participation in the 80,000-member SAE, which he considers the most influential organization of its kind in the world. "I've tried to be an ambassador for the public sector," he says. "I frequently remind my SAE colleagues of the importance of bringing the government in on things early on and in a positive way. Most are accustomed to dealing with government in the regulatory arena. However, when they come into contact with the side of government that is focused on developing technology and addressing public policy issues, many are frankly surprised to find how similar we are. They come to realize that our perspectives may differ, but the way we work and what we care about are very much the same. I'd like to think that this realization has been a factor in a number of very successful projects we've had with multiple, major industrial sponsors."

Larsen's active involvement in the SAE and his commitment to a vigorous public-private sector dialogue were both factors in his election in 1997 to the SAE Board of Directors. It was a first for a member of the Argonne/DOE family and only the third time someone from the public sector has been elected to that august board.

He concluded his three-year board term in March, but the bridge building that got him elected continues. A May 3 meeting at Argonne was textbook Larsen. Seated around a conference table at the Center for Transportation Research were some high-powered guests. Foremost among them was Neil Schilke, newly elected SAE president and general director of engineering at General Motors Corp. Also present were Rodica Baranescu,

the SAE's immediate past president and chief engineer of the Engine Technical Center at International Truck and Engine Corp.; Ray Morris, executive director of SAE products and services; and Edward Widder, chairman of the SAE's Chicago section and senior research engineer at Federal-Mogul Corp.

After welcoming their guests, Larsen and Larry Johnson, director of Argonne's Transportation Technology Research and Development Center (TTRDC), clicked through a PowerPoint presentation showcasing the research center's programs. Schilke reciprocated with a one-hour presentation: "A Systems Approach to R&D: Benefits of Participation in SAE and Opportunities for Collaboration in the Mobility Industry of the

Future." In the afternoon, the entourage toured the Advanced Photon Source and test facilities housing the center's research on advanced powertrains, fuel cells, batteries, and locomotives.

For Larsen, the forum was just the kind of exchange essential for the ongoing success of public-sector transportation programs. The meeting also underscored the strength of the relationships that Larsen established during his board tenure and through his lifelong participation in the SAE.

Baranescu — who was the SAE's first woman president — acknowledges

that, "Sometimes in industry, we tend to see the government on the other side — as an adversary rather than as a partner working together to achieve common goals. As a board member, Bob was continually bridging the gap, the way we should all be doing."

Schilke goes one step further. "Bob has become a good friend and an important professional colleague. I've come to hold him in very high regard for his professional integrity, technical expertise and experience, collegial attitude, and friendly personality. He brought all those assets to the SAE Board and was effective in helping the SAE make progress on many fronts. There's no question that he did an outstanding job of representing the technical/R&D community and public sector, which was enormously important in providing balance in our board deliberations."

The respect is mutual. Schilke was Larsen's staunchest ally on an important initiative. Shortly after joining the Board, Larsen





was asked to chair the Environmental Responsibility and Economic Sustainability Committee. For nearly two years, the committee's work was the flashpoint for a spirited debate about the role of the SAE in dealing with the environment and energy depletion (i.e., not foreclosing the options of future generations by actions taken today). That effort culminated in a far-reaching policy change for the society. It was a tough sell, "requiring two readings, two votes, and a lot of wordsmithing." But the 24-member Board concluded that the SAE had a role on both issues and approved a new strategic initiative.

Larsen credits the support and political prowess of Schilke, who was treasurer at the time, as pivotal in ultimately winning that approval. He also sees the initiative as his biggest accomplishment during his board tenure. "This is the kind of fundamental change of philosophy and direction that's going to positively affect the health of the organization." Work is already under way to implement the policy. One of the first acts of a newly established environmental sustainability standing committee was to create an Environmental Excellence in Transportation Award.

Larsen also championed another Board initiative that resulted in increased SAE support for academia, including funding for more engineering fellowships and expanded vehicle competition programs (popular worldwide with the SAE's 10,000-plus student members).

In addition, Larsen was pleased to be part of the SAE's ongoing efforts to position itself as an international organization. During his tenure, the Board met in Germany, Austria, and Mexico, reflecting a decision to schedule at least one "listening" meeting per year overseas.

On a personal level, Larsen enjoyed the new insights he gained on the SAE governance processes. In fact, he was required to

complete a one-year "orientation" program before officially joining the Board — a move he says enabled him to be immediately productive. "One of the great learning experiences was coming to understand the management process of a large technical society. The SAE has done a good job of evolving a governance system that has well-defined roles for everybody in the organization. The management principles embodied for the Board of Directors keeps the focus on policy-level and strategic planning areas — setting the overall direction for the society. It discourages the board from getting involved in detailed operating decisions."

Likewise, some of his fellow Board members gained new insights into the stewardship role of government. Larsen's behavior on the board was observed by Baranescu, who notes that, "because of his government work, he was very careful in using resources wisely and efficiently for various activities and personnel. This reflects the discipline of being in a government body and the culture of being aware of resource spending."

While the relationship between Larsen and the SAE has been mutually beneficial, does it have long-term value? It should. As a Board member, Larsen met many of the movers-and-shakers in the non-road transportation sector — which includes agriculture, mining, and construction. DOE is planning to work with this sector on new initiatives that promote cleaner, more efficient propulsion systems, and Larsen's contacts should prove valuable in that effort.

In the meantime, Larsen remains an active SAE member at the national and local levels. He is on the Advanced Power Plant Committee and has recently completed a three-year term on the Strategic Planning Committee. Since leaving the Board, he has been courted for other committee assignments. "He is sought after by many groups who need his technical and strategic thinking skills," says Schilke.



## Debut of Hybrid Electric Vehicles Heats Up Interest in Underhood Thermal Management

*Researchers Propose New Codes to Improve Underhood Modeling of HEVs*

Amidst a great deal of fanfare last year, the Toyota Prius joined the Honda Insight as the only hybrid electric vehicles (HEVs) mass-produced for the North American market. U.S. manufacturers have also unveiled prototype HEVs that should hit the market within the next few years.

These first-generation HEVs are the most technologically advanced vehicles ever made, combining a gasoline-pow-

ered engine with a battery and electric motor. They bring together the "best of both worlds"— the extended driving range and easy refueling of the conventional automobile and the fuel economy and environmental benefits of an electric vehicle. They're also a harbinger of things to come. Automotive analysts now predict that carmakers will roll out as many as 30 more HEVs by 2010.



The technological complexity of these HEVs is of interest at Argonne, where researchers in thermal management have been working with industry partners on high-performance computer models that simulate complex fluid flows and heat transfer in the underhood systems of cars, including HEVs. The goal of this pioneering work is to improve underhood heat-load modeling, especially as it relates to emissions and fuel efficiency.

“Aerodynamics, packaging, and styling changes that reduce the size of the underhood compartment and front openings can have an adverse impact on the underhood thermal environments,” says Adrian Tentner, director of Argonne’s Intelligent Transportation Systems program. “The result can be higher emissions, reduced fuel efficiency, and damage to sensitive electronic components.”

Automakers have been addressing these issues in conventional cars by using system analysis codes — primarily the PSAT and ADVISOR codes developed with U.S. Department of Energy (DOE) funding — and modern computational fluid dynamics (CFD) computer codes, such as the STAR-CD codes by Analysis and Design Application Company, of Melville, New York. The CFD codes are being used in tandem with experimental data to improve the performance of individual underhood components.

Despite the significant advances in underhood thermal management, hybrid cars remain largely uncharted territory. The addition of significant new thermally active components, such as the power electronics system, creates challenges for both system analysis codes and the component design CFD codes. “We need to better understand what happens under the hood of the hybrid as well as other, more advanced vehicle designs,” notes Tentner. “There is little underhood experimental data about how these vehicles behave, so you cannot calibrate the thermal management systems code based on experience. What are needed are more detailed CFD codes that get this information for the systems analysis codes to help users get realistic, reliable results.”

Under Tentner’s leadership, Argonne recently completed a proof-of-concept project in which researchers investigated the merits of using high-fidelity CFD codes — along with the industry-accepted system analysis codes — to analyze underhood thermal phenomena in hybrid cars. At the end of the six-month effort, using the STAR-CD CFD code, researchers found that “yes, computational fluid dynamics can be used to model the geometry of hybrid engines and heat transfer in the underhood space, and provide the parameters needed to enhance the system analysis codes, resulting in improved evaluations of emissions and fuel efficiency.”

Argonne researchers are planning to follow up their preliminary



*Argonne researchers are working with industry partners on computer models that simulate complex fluid flows and heat transfer in the underhood systems of HEVs (copyright, Edward J. Plaskacz, Argonne National Laboratory).*

findings by extending the STAR-CD modeling capabilities to include hybrid-specific components and thermal underhood loads.

Interfacing the new modeling capabilities with the system codes would allow a more accurate analysis of integrated hybrid-vehicle propulsion designs.

Tentner is especially eager to take advantage of the experimental capabilities of Argonne’s Advanced Powertrain Test Facility; these capabilities are essential tools for validating various computations, an area in which Argonne researchers have traditionally excelled.

According to Tentner, “If we just run the computations, we can never be sure they are correct. We need to run a set of experiments on the vehicle and analyze the data. If we can obtain correct computational results, we will be able to replace future experiments with computer simulations of various situations. That will save time and money. With relatively little additional effort, the models can be extended to the analysis of other vehicles.”

The modeling work to date was sponsored by DOE’s Office of Advanced Automotive Technologies.

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## Ceramic Engine Components Endure Over the Long Haul

*Advanced fuel injectors and engine valves offer high durability*

Today's heavy-duty diesel truck engines are typically designed to have a lifetime of one million miles or more. Lightweight, wear- and corrosion-resistant engine components are needed to keep these engines running reliably over the long haul. Some — such as fuel injectors with ceramic components — can last longer and reduce emissions by better controlling the combustion process. However, any ceramic part designed for use in a diesel engine component must be machined precisely and must not have any machining-induced damage that could cause the component to fail.

“As manufacturers advance machining technology to reduce costs and obtain faster removal rates (the time during which the material is shaped by the machining operation), they need to know what kind of damage they're inducing in these ceramic parts by their manufacturing processes,” says Bill Ellingson, Senior Mechanical Engineer in Argonne's Energy Technology Division.

Argonne is developing a patented, cost-effective method to ensure the quality of ceramic engine parts after machining. Researchers are using a low-power laser — similar to those

installed at grocery store checkout counters. By focusing the laser light onto the part and then carefully studying the way the laser light scatters, Argonne's researchers are demonstrating that they can characterize the amount and location of any damage. They can locate the damaged regions either on or below

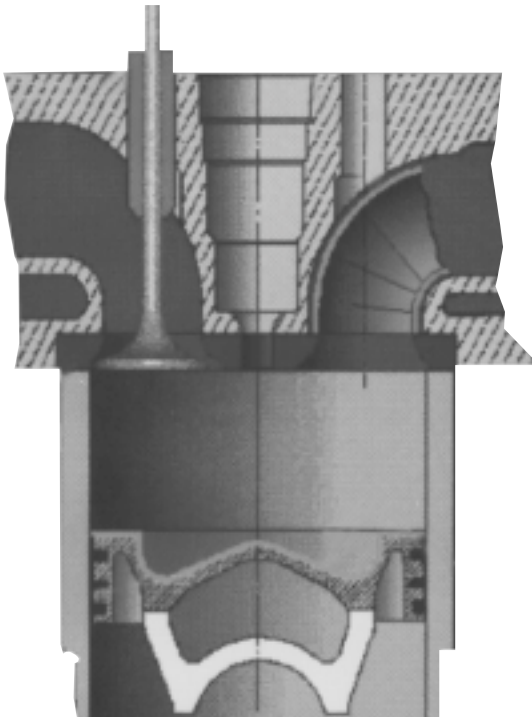
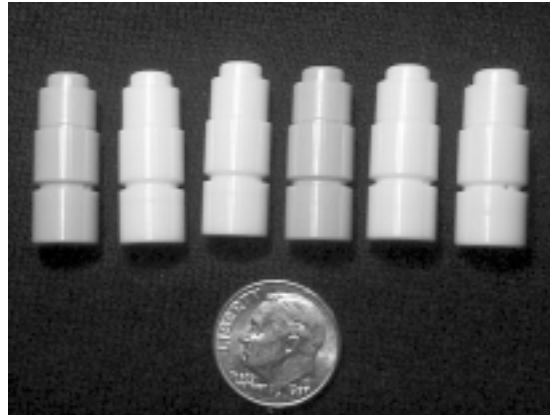
the surface of ceramic parts — such as valves — and relate the detected damage to changes in the strength of the ceramic material. The strength of the material plays a significant role in determining whether the part will fail.

Funded by the U.S. Department of Energy, Argonne is also collaborating with several major manufacturers involved in developing ceramic materials for use in engine components. In one initiative, Caterpillar

Inc. lent its expertise and experience in developing the Argonne damage detection method for a silicon nitride diesel engine valve. The goal of the program is to investigate methods developed by Argonne to detect damage in ceramic valves caused by aggressive machining conditions.

In another effort, Cummins Engine Company has designed a high-pressure fuel injector and the ceramic parts in it. A fuel injector is the “Achilles heel” of a long-haul diesel engine, because if it doesn't operate properly, the combustion pattern is disturbed. This disturbance results in incomplete combustion in the engine and unacceptable emissions.

Recently, Cummins provided a set of test samples with known damage to allow demonstration of Argonne's method. The results of the demonstration will provide the basis for the company to consider testing the Argonne method in a production environment.



*Argonne is working to improve the reliability of ceramic engine components such as fuel injector components (top) and valves (left) by using low-power lasers to detect subsurface damage.*

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## Ultra-Tough Carbon Coatings Are Finding Many Underhood Uses

*Argonne's near-frictionless coatings are helping automotive companies comply with new governmental regulations*

More trucks are in use today than ever before, and even though diesel truck emissions have been greatly reduced over the years, further cuts are needed. The U.S. Environmental Protection Agency (EPA) has scheduled more restrictive emissions quotas for 2004 and proposed even tougher standards for 2007. Meeting such strict standards will mean reducing the sulfur content of diesel fuel and developing more advanced engine and emission-control technologies.

The impact of the EPA mandates will fall heaviest on diesel fuel-injection components, particularly injectors and fuel pumps. Fuel injectors, which already operate at 20,000 psi, will be expected to function at pressures of at least 30,000 psi and perhaps even 45,000 psi. Because an injector thrusts fuel into a cylinder by means of a plunger sliding inside a barrel, higher pressures mean smaller clearances between the two components, leading to reliability and durability issues. The main concerns involve wear and scuffing. Reducing the sulfur content of diesel fuel heightens the probability of wear and scuffing failures because there is less sulfur present to lubricate contacting surfaces with a slippery film of iron sulfide.

Argonne was among the first research organizations to offer a solution to higher injection pressures and reduced sulfur levels with its near-frictionless carbon coating technology. There are now many commercial diamond-like carbon coatings in the marketplace, but Argonne's ultra-hard films remain among the best in wear resistance and low-friction characteristics. "Our coatings exhibit the best friction coefficients in an inert atmosphere and the lowest coefficients that I have seen for dry sliding in air," says George Fenske, ANL's Tribology Section Manager. "They also have shown a very high resistance to scuffing."



*Argonne is working with CemeCon to adapt the company's production-scale deposition system to coat components with near-frictionless carbon films.*

Argonne's Tribology Section is working with Diesel Technology Corp. to develop near-frictionless carbon coatings for the company's heavy-duty diesel fuel-injector plungers. The results have been so promising that the Argonne group has begun focusing on coating the plungers and other automotive components on a commercial scale. Argonne has also entered into a Cooperative Research and Development Agreement (CRADA) with CemeCon to adapt the company's CC800/9 deposition system for coating components in 1,000- to 3,000-piece batches.

Fuel-injector plungers are by no means the only emerging application area for Argonne's coating technology. The group is also working with companies that are interested in coating critical surfaces in fuel pumps, hydraulic fluid pumps, and even heavy-duty truck axles. Fenske and his colleagues are also investigating using the coatings on fuel injector tips, cams, and turbocharged rotors. Yet another new application involves coating components in compressors designed to force air through fuel cells. "Many of these systems have components that cannot have any organic lubricant on them," Fenske explains. "Under those conditions, frictional losses can be quite high without an inert, low-friction coating like ours."

Perhaps the most exciting new area for the group involves the prospect of developing ultra-hard, low-friction coatings for micromachines. The group hopes to begin working with scientists from Northwestern University on nanotech devices that would gather information about engine performance while operating inside the running engines.

The group continues to maintain a strong commitment to basic research. Its members are now working at Argonne's Advanced Photon Source (APS) to gain a fundamental understanding of how lubricants interact with surfaces. The high brilliance of the APS enables them to do tests with oil films present; other techniques require that oil be removed. The group plans to eventually conduct dynamic tests under realistic loads and stresses at the APS.

This work was funded primarily by the Office of Advanced Automotive Technologies, part of DOE's Office of Transportation Technologies, and by the Office of Science.

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Just as we were about to go to press with this issue of TransForum, the September 11 terrorist attacks occurred. Suddenly, it is no longer business as usual. Now seems a good time to review our energy priorities as a nation, and perhaps the following numbers provide a starting point.

Geologists' best estimates of the world's ultimate supply of petroleum are about 3 trillion barrels. We have already used more than a quarter of these petroleum resources, and each year we consume oil at a faster rate — we now use 75 million barrels per *day*. Transportation drives the demand for oil; over the last 25 years, 80% of the increase in oil demand was caused by growth in transportation oil consumption and, in developing countries, this growth will outstrip that in the United States. China, for instance, has a vehicle ownership rate of 12 vehicles per 1,000 people — which is about where the United States was in 1913. Today, there are about 800 vehicles per 1,000 people in this country. By 2020, the world will likely have consumed more than half its oil resources and will begin a permanent decline in oil production. These issues are in addition to concerns about long-term global warming trends. This was all true *before* September 11.

Now energy security is emerging as a national priority. Half our oil is imported and more than half of our imported oil is from OPEC countries. While many of us in government and industry have worked to develop technologies to improve the energy efficiency of vehicles, the fuel economy of the U.S. light-duty fleet has actually declined over the past decade: peaking at 26.2 mpg in 1987 and steadily declining to 24.5 mpg in 1999. The price of gasoline has simply not been high enough for people to demand more efficient vehicles.

Looking back since the oil price shock caused by the 1973-74 OPEC oil embargo, we can see that the three subsequent major oil price increases followed sharply increasing dependence on OPEC; oil price declines occurred when the U.S. reversed its dependence. Wars within the Middle East or terrorism from the Middle East have led to instability in oil supplies, exacerbating oil price movements. Recessions typically follow upward oil price shocks. High oil prices also result in considerable transfer of wealth from industrialized countries to oil-exporting countries.

As our growing population travels more in less efficient vehicles, we increase our nation's vulnerability to petroleum supply disruption, and we also increase the probability of such a disruption. We have to review our transportation and energy priorities. In business and government, people have contributed to economic growth by doing more with less — increasing the productivity of our nation. Unfortunately, transportation is one important area that has been neglected. Now, we should ask ourselves if we can provide more transportation services using less energy. The events of the last several weeks have made it starkly clear that — now more than ever — energy efficiency is in the national interest. While we look for ways to make a difference in the wake of the terrorists' tragedy, we should ask ourselves: are we doing all we can to make energy efficiency a reality?



*Larry*

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*Crain's Chicago Business* has named Argonne research engineer **Michael Duoba** to its "40-Under-40," an annual roundup of young people who are making news and breaking new ground in Chicago. Described as "one of the world's leading experts on hybrid vehicles," the 32-year-old Duoba has designed, built, and tested advanced batteries for electric vehicles at Argonne. Currently, he is the principle investigator at the Advanced Powertrain Test Facility, which is used to test hybrid electric components, systems, and vehicles to support technology validation and benchmarking.

Duoba — who earned a masters degree in mechanical engineering from the University of Wisconsin — commutes from downtown Chicago in a 1992 Honda Civic, but "tools around

the lab in the Toyota Prius and the Honda Insight, two hybrid vehicles just coming on the market." Crain's also notes that Duoba paints and records his own rock music in his spare time.

Duoba's under-40 colleagues comprise a diverse group of Chicago movers and shakers, including corporate CEOs, government officials, attorneys, physicians and technology and financial entrepreneurs as well as a playwright, a chef, a law professor, and a musician.

Visit Crain's Website for the full story ([http://www.chicagobusiness.com/cgi-bin/article.pl?feature\\_id=7&page\\_id=781](http://www.chicagobusiness.com/cgi-bin/article.pl?feature_id=7&page_id=781)).





Industrial technology development is an important way for the national laboratories to transfer the benefits of publicly funded research to industry to help strengthen the nation's technology base. The stories highlighted in this issue of *TransForum* represent some of the ways Argonne works with the transportation industry to improve processes, create products and markets, and lead the way to cost-effective transportation solutions, which in turn lead to a healthier economic future.

By working with Argonne through various types of cost-sharing arrangements, companies can jump-start their efforts to develop the next generation of transportation technologies without shouldering the often-prohibitive cost of initial R&D alone. Argonne has participated in dozens of these partnerships and has even been involved in helping to launch startup companies based on the products and technologies developed here.

If working with world-class scientists and engineers, having access to state-of-the-art user facilities and resources, and leveraging your company's own capabilities sound like good business opportunities to you, please contact our Office of Technology Transfer and see how we can put our resources to work for you.

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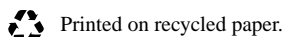
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